DECLARATION OF **Neal CHUNG Tai-Shung**
Relating to U.S. Patent Application **10/719,869** Filed **14 November 2003**

1. I hereby declare that all statements made herein of my own knowledge are true and that all statements made on information and belief are believed to be true; and further that these statements were made with the knowledge that willful false statements and the like so made are punishable by fine or imprisonment, or both, under Section 1001 of Title 18 of the United States Code and that such willful false statements may jeopardize the validity of the application or any patent issued thereon.

2. I am a named inventor for the patent application **10/713,869** filed **14 November 2003**, entitled **Polyimide Membranes** ("the Application") and as such have knowledge of the facts contained herein.

3. I am a Professor at the Department of Chemical and Environmental Engineering Department at the National University of Singapore. I specialize in membrane science and engineering, and in particular, liquid/gas/pharmaceutical separation and high performance polymers. My curriculum vita is enclosed in **APPENDIX I** of this Declaration.

4. I have reviewed the document WO99/40996 ("Document D1"). Document D1 teaches a process for forming selective composite membranes. The process comprises providing an asymmetric membrane base having pores in at least the upper layer thereof, and exposing the porous membrane base to a coating solution. The membrane base can be a polyimide membrane. The coating solution comprises polymers and/or oligomers which forms a selective barrier coating on the surface of the membrane base and on the surfaces of the pores within the membrane base. Crosslinking agents such as non-polymeric or oligomeric polyfunctional compounds can be added to the coating solution to crosslink the polymers and/or oligomers in the solution.

5. The process for treating a membrane being comprised of polyimide, as defined by the claims of the Application, provides a treated polyimide membrane having high selectivity and high gas permeability which is suitable for use as a gas separation membrane or as a pervaporation membrane. The process comprises the steps of (a) directly exposing the polyimide to a dendrimer in a solvent and (b) maintaining said solvent containing said exposed polyimide and said dendrimer at a temperature less than 100°C and for a time to allow the dendrimer to crosslink the polyimide and thereby form the treated polyimide membrane having the above-outlined properties.

6. The feature of directly exposing the membrane of the type used in gas separation or pervaporation, the membrane being comprised of polyimide, to a dendrimer (i.e., crosslinking agent) as defined by the claims of the Application is not taught nor suggested at all in Document D1.

7. Furthermore, the process, as defined by the claims of the Application, results in surface modification (i.e., only the surface of the membrane is

crosslinked) of the polyimide membrane, and not the formation of a separate selective barrier coating on the polyimide membrane base as taught in Document D1.

8. It should be noted that in the process of Document D1, the membrane base has to be a porous asymmetric membrane base, which when treated, is suitable for use as a Reverse Osmosis (RO) membrane, Nano-filtration (NF) membrane, Ultra-filtration (UF) membrane or Electrodialysis (ED) membrane. Such membranes are generally employed for the separation of liquid mixtures and are not suitable for separating gas mixtures in view of their pore sizes. For instance, the pore sizes of RO, NF and UF membranes are typically 0.7nm, 1-10nm and 20-2000 nm respectively, which are too large for gas separation or pervaporation purposes. Accordingly, the feature of the membrane of the type used in gas separation or pervaporation, the membrane being comprised of polyimide, is also not taught nor suggested at all in Document D1.

9. In my view, Document D1 does not disclose each and every essential feature of the claims of the Application. Claims 1, 4, 5, 8 to 15, 17, 29 and 30, in their current forms, are therefore novel over the Document D1.

10. The direct exposure of the membrane of the type used in gas separation or pervaporation, the membrane being comprised of polyimide, to a dendrimer under the defined conditions results in a treated polyimide membrane having high gas permeability and high selectivity, as can be seen in Examples 1 to 3 on pages 9-15 of the Application.

11. Although crosslinking can modify the polyimide membrane to result in improved selectivity, it can also result in densification of the membrane which in turn reduces permeability. As gas separation membranes or pervaporation membranes are generally of a dense structure, the dendrimer cannot penetrate deep into the membrane structure and the crosslinking reaction is therefore limited to the surface of the membrane. Accordingly, the bulk of the membrane structure below the crosslinked membrane surface remains unmodified or undensified. The polyimide membranes treated with the process as defined by the claims of the Application therefore have a high selectivity and high gas permeability.

12. The technical advantages outlined in Statements 10 and 11 above resulting from the process as defined by the claims of the Application are not taught nor suggested at all in Document D1.

13. As mentioned in Statement 8 above, Document D1 does not teach a process for treating a membrane of the type used in gas separation or pervaporation, the membrane being comprised of polyimide, as it is an essential requirement in the process of Document D1 that the membrane base be porous. Furthermore, Document D1 also does not suggest the use of the selective composite membranes in the separation of gas mixtures or in pervaporation. In my view, a skilled technician who is knowledgeable in the field of membrane technology, would not be readily motivated to try or understand that the process as disclosed in Document

D1 can be applied to a membrane of the type used in gas separation or pervaporation, the membrane being comprised of polyimide.

14. In the process disclosed in Document D1, the coating solution penetrates into the pores of the membrane base by means of convection and diffusion mechanisms, thereby resulting in the crosslinking of the polymers and/or oligomers(in the coating solution) occurring on both the surfaces of the membrane base and the pores within the membrane base to form the selective barrier coating.

15. On the other hand, as mentioned in Statement 11 above, in the process as defined by the claims of the Application, the dendrimers react only with the surface of the membrane. Only an insignificant amount of the dendrimers may penetrate underneath the surface by diffusion.

16. In my view, a person skilled in the art, in reading the disclosure of WO99/40996, will not be motivated to or be able to derive the present invention as defined by the claims of the Application. I am also of the view that the claims are not obvious in light of the disclosure of WO99/40996. Claims 1, 4, 5, 8 to 15, 17, 29 and 30, in their current forms, are therefore inventive over Document D1.

AND I MAKE this solemn declaration, conscientiously believing the statements contained in this declaration to be true in every particular.

(Neal) Tai-Shung Chung   July 8, 06

Neal CHUNG Tai-Shung   Date

APPENDIX I

CURRICULUM VITA OF PROF. NEAL T. S. CHUNG

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National U of Singapore
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Technical: Ph.D. Chemical Engineer specializing in membrane science and engineering, liquid/gas/ pharmaceutical separation and high performance polymers

- Expert and internationally known in membrane separation and liquid crystalline polymers.
- Editorial Board Members of
  1. Separation and Purification Reviews (former Separation and Purification Methods which had an Impact factor = 6.6 in 2004)
  2. Journal of Membrane Science (Impact Factor = 2.1 in 2004)
  3. Polymer Engineering and Science (Impact Factor = 1.224 in 2004)
  4. Journal of Applied Polymer Science (Impact Factor = 1.02 in 2004)
  5. Euro-Asian Journal of Applied Sciences
  6. European Journal of Scientific Research
- Editor for the Applied Membrane Science and Technology Journal
- One of the most highly cited NUS professors with science citation numbers of more than 200 times per year in years 2003, 2004 and 2005.
- An author of 1 book, 11 book chapters, 250 journal papers and more than 120 conference papers.
- Received R & D grants of about S$9 millions in last 10 years in NUS.
- Conducted joint research with Hitachi DuPont (1998-1999), British Gas (1998-2001), UOP (2003-2006), Merck (2003-2006), Mitsui (2005), BASF (2005-2007), Hyflux (2005-2008) and others.
- A part of the team invented, developed and commercialized Vectra™ liquid crystalline polymers with the annual business size of US$150 million.
- An inventor of about 70 patents (including 33 US patent) and patent applications, the highest patent holder in NUS. Several of them commercialized.
- Consultant for Air Products (USA) in 1998-1999
- Senior Consultant for Hyflux (Singapore) in 2004-2005
- 15-year industrial R& D experience in the US industry (13 years in Hoechst Celanese).

Management:

- Demonstrated managerial capability of managing multi-functional teams, project planning, joint R & D collaboration, technology and product development, and business plans.
- Progressed from Program Coordinator, Program Director, to the Deputy Director of the Institute of Materials Research and Engineering (IMRE) in 1996-2001, hand built the biggest R & D group in IMRE with more than 50 staff and the highest cost recovery of more than 30% by conducting world-class R & D and developing multi-million external R & D grants.
- A strong connection with research institutes, universities and industries in China, Taiwan and USA

EMPLOYMENT EXPERIENCE

July 2001 to the present	Professor, Dept of Chemical & Environmental Engineering, NUS (http://www.chee.nus.edu.sg/staff/000731chungts.html)
Jan 2001 to Aug 2001	Cluster Director, Institute of Materials Research and Engineering (IMRE) Lead fundamental, technology and industry driven researches in the National Lab in the areas of Polymers and Chemicals for electronic devices, separation & purification, and controlled release devices.
June 2000 to Dec 2000	Deputy Director, Institute of Materials Research and Engineering (IMRE)
Feb 2000 to July 2001	Professor (Research), Dept of Chemical & Environmental Engineering, NUS
1998-2000	Program Director, The Advanced Polymers and Chemicals Program, IMRE
1995-2000	Associate Professor, Dept of Chemical & Environmental Engineering, NUS
1997-1998	Program Manager, The Advanced Polymers Program, IMRE
1996-1997	Program Coordinator, The Advanced Polymers Group, IMRE
1993 to 1995	Project Manager/Consulting Engineer Aeroquip Corporate Technology Lab., Ann Arbor, Michigan
1988 to 1993	Research Associate (equivalent to the Group Leader or Technical Manager) Hoechst Celanese Research Division, New Jersey
1986 to 1988	Staff Engineer (equivalent to Project Leader), Hoechst Celanese Research Division, New Jersey
1983 to 1986	Senior Research Engineer, Hoechst Celanese Research Division, New Jersey
1980-1983	Research Engineer, Hoechst Celanese Engineering Resins Company, New Jersey
1977-1980	Research Assistant, Dept. of Chem. Eng., State University of New York at Buffalo
1975-1973	Research Assistant, Dept. of Chemical Engineering, National Taiwan University

PERSONAL

Singapore PR, US citizen, Christian; married with two lovely children.